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NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *July 21, 2005*

Lieutenant Suffers a Heart Attack While Driving a Squad Truck and Dies Four Days Later – Georgia

SUMMARY

On February 15, 2005, a 51-year-old male career Lieutenant (LT) assisted in washing a Fire Department (FD) engine and a squad truck. When driving the squad truck to his fire station he suddenly collapsed onto the seat. The squad truck ran off the road and crashed over an embankment. Two witnesses in a nearby store parking lot saw the accident and notified 911, who dispatched an ambulance and the FD. Cardiopulmonary resuscitation (CPR) was performed, advanced life support (ALS) treatment was given, and the LT was transported to the local hospital's emergency department (ED). In the ED, he was noted to have a heart attack and was transferred to a regional hospital for emergent cardiac catheterization and angioplasty. Despite these procedures and other ALS measures, the LT died 4 days later. The death certificate, completed by the County Coroner, listed "anoxic encephalopathy" due to "sudden cardiac arrest" due to "atherosclerotic cardiovascular disease" as the cause of death. The autopsy, completed by the State Chief Assistant Medical Examiner, listed "anoxic encephalopathy" due to "cardiac arrest" due to "atherosclerotic coronary vascular disease with acute thrombosis of the right coronary artery" as the cause of death. The NIOSH investigator concluded that the LT's heart attack and eventual death was due to his underlying atherosclerotic coronary artery disease (CAD) possibly triggered by the physical exertion associated with washing the engine and the squad truck.

NIOSH investigators offer the following recommendations to prevent similar incidents or to address general safety and health issues:

Provide pre-placement and annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Consider conducting exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

Phase in a MANDATORY wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

Staff all fire stations with a minimum of two fire fighters.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at **www.cdc.gov/niosh/firehome.html** or call toll free **1-800-35-NIOSH**

Lieutentant Suffers a Heart Attack While Driving A Squad Truck and Dies Four Days Later – Georgia

INTRODUCTION & METHODS

On February 15, 2005, a 51-year-old male LT suffered a heart attack while driving a squad truck to his fire station. Despite CPR and ALS performed by crew members and EMS personnel, and cardiac catheterization and angioplasty by hospital personnel, the LT died four days later. NIOSH was notified of this fatality on February 22, 2005, by the United States Fire Administration. NIOSH contacted the affected FD on February 23, 2005, to obtain further information, and on March 24, 2005, to initiate the investigation. On April 18, 2005, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Georgia to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the following persons:

- Fire Chief
- Crew members
- LT's wife

NIOSH personnel reviewed the following documents:

- FD incident report
- FD training records
- FD annual response report for 2004
- FD standard operating guidelines
- Ambulance report
- Hospital records
- Death certificate
- Autopsy report

INVESTIGATIVE RESULTS

On February 15, 2005, the LT arrived for duty at his fire station (Station 4) at 0700 hours. Two fire fighters (FFs) were scheduled to work; the LT and another career Fire Fighter. This FD is also staffed by volunteer FFs who respond to emergency calls by their personal vehicles. Additional FD apparatus staffed with career personnel respond from other fire stations as necessary.

Throughout the morning the LT and the FF checked the fire apparatus and equipment. The LT then performed paperwork until around lunchtime, when he delivered two smoke detectors to Station 12 and returned to his fire station. The LT and the FF washed and rinsed the Engine and the Squad truck. The LT left the fire station at about 1315 hours to air dry the Squad truck. At about 1331 hours, the LT drove through an intersection, waved at a Deputy Sheriff, continued another ¾ mile, through another intersection, and collapsed onto the seat. Two witnesses in a nearby store parking lot, seeing the accident, notified 911.

At 1334 hours, Engine 4 and an ambulance were dispatched to "an accident with injuries involving a fire truck." While units were en route, Dispatch notified them that there was a "possible cardiac arrest and entrapment." Unit 801 (Fire Chief) was dispatched at 1335 hours. Engine 4 arrived on the scene at 1336 hours and noted that Squad 4 was about 15 feet down an embankment. Witnesses related that the truck veered off the road and made no apparent attempt to stop.

The FF from Engine 4 retrieved the medical jump kit and the automated external defibrillator (AED) and proceeded down the embankment to the Squad truck. He opened the driver's door and noted the LT was still seated in the driver's seat but slumped over with the seat belt partially across his midsection. The FF found the LT unresponsive with no respirations, no pulse, and cyanotic skin color. The FF requested a bystander retrieve a backboard from Engine 4 and bring it to the Squad truck.

The FF and other bystanders extricated the LT from the Squad truck out the passenger side door and placed him onto the ground. The FF rechecked the LT's vital signs. Finding no pulse and respirations, CPR was begun. The FF inserted an oral airway and bystanders began assisted ventilations via bag-valve-mask and chest compressions. The FF applied the AED to the LT, no shock was advised, and CPR continued. Engine 1 was dispatched at 1339 hours to "an entrapment." The FF advised Dispatch that there was no entrapment, but a cardiac arrest. Prior to the ambulance arrival, the AED analyzed the LT's heart rhythm four times. Two times it advised a shock and a shock was delivered with improvement in his clinical condition.

Units 803 (Deputy Chief), 806 (Division Chief), and Squad 3 were dispatched between 1345 hours and 1346 hours. As FD personnel arrived on the scene, a call was made to Dispatch to identify which ambulance was responding. Upon learning that the unit responding was staffed with the LT's wife, a paramedic, a request was made to dispatch another ambulance.

A second ambulance was dispatched and arrived on the scene. Initial assessment by the paramedics revealed an unresponsive patient, with no pulse, no respirations, and CPR in progress. He was intubated (breathing tube inserted into his trachea) and placement was verified by auscultation (bilateral breath sounds) and confirmed by end tidal carbon dioxide (CO_2) measurement. A cardiac monitor revealed pulseless electrical activity (heart rhythm incompatible with life). Cardiac resuscitation medications were administered and the LT's heart rhythm changed to ventricular fibrillation (Vfib). He was shocked (defibrillated) and his heart rhythm changed to sinus tachycardia (rapid heart rate) with a pulse rate of 146 beats per minute (bpm) and blood pressure (BP) of 90/50 millimeters of mercury (mmHg). Shortly thereafter, his heart rhythm reverted to Vfib and he was defibrillated again. Again, this converted his heart rhythm to sinus tachycardia with a pulse rate of 148 bpm and a BP of 100/60 mmHg. He was placed into the ambulance, which departed the scene en route to the hospital.

The ambulance arrived at the hospital ED at 1400 hours. Initial evaluation in the ED found the LT to be unresponsive, taking an occasional respiration, with a heart rate of 146 bpm and a BP of 144/95 mmHg. At 1430 hours, his heart rhythm reverted to ventricular tachycardia (Vtach) and he was defibrillated. Additional cardiac medications were administered and his heart rhythm changed to normal sinus rhythm at a rate of 107 bpm and a BP of 154/90 mmHg. Assisted ventilations via bag-valve-mask continued. Cardiac isoenzymes (a blood test used to confirm heart muscle damage) revealed an elevated troponin level of 0.39 nanograms per milliliter (ng/mL) (normal 0.00 ng/mL– 0.06 ng/mL). An EKG showed clear signs of an acute inferior wall heart attack, medically known as a myocardial infarction (MI). His care was transferred to a cardiologist who emergently inserted an intra-aortic balloon pump to assist circulation to his vital organs.

At 1644 hours, the LT was flown to a regional hospital for emergent cardiac catheterization. Arriving at the hospital at 1703 hours, emergent cardiac catheterization revealed 100% stenosis (blockage) of his right coronary artery (RCA) by a thrombus (blood clot) and severe left ventricular inferior and lateral wall hypokinesis with an ejection fraction of 30%-40%. The RCA was opened via angioplasty and a stent was successfully placed. The placement of the intra-aortic balloon pump was complicated by a local distal

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aorto- and ileo-femoral dissection and the pump was removed.

Despite stabilization of his heart rhythm and blood pressure, the LT never regained consciousness. A subsequent head computed tomography (CT) scan revealed "severe generalized edema (swelling) of the entire brain with findings suggestive of global hypoxia or anoxia (lack of oxygen) due to prolonged cardiac arrest." An electroencephalogram (EEG) revealed no higher brain function. His hospital course did not show any improvement, and on February 19, the decision was made to remove the LT from life support. He was pronounced dead by his physician at 0510 hours.

Medical Findings. The death certificate, completed by the County Coroner, listed "anoxic encephalopathy" due to "sudden cardiac arrest" due to "atherosclerotic cardiovascular disease" as the cause of death. The autopsy, performed by the State Chief Assistant Medical Examiner on February 19, 2005, included the following findings:

- Enlarged heart (cardiomegaly): heart weighed 450 grams (normal < 400 grams)[1]
- Ischemic heart disease:
  - Moderate narrowing (40%-50%) of the right coronary artery
  - Mild narrowing (30%–40%) of the left anterior descending coronary artery
- No evidence of pulmonary thromboemboli
- Negative drug and alcohol tests

Microscopic examinations revealed the following:

- An acute hemorrhagic infarct (heart attack) of the posterior wall of the heart's left ventricle
- Focally calcified atherosclerosis (50% - 60% luminal stenosis) in the right coronary artery just proximal of the stent

Primary care physician (PCP) medical evaluations from 2004 revealed the following CAD risk factors:

Hypercholesterolemia. The first elevated total cholesterol reading was in April 2004 (246 milligrams per deciliter [mg/dL]) (normal 50 mg/dL-200 mg/dL), with an elevated low density lipoprotein (LDL) and a normal high density lipoprotein (HDL) level. The elevated cholesterol was successfully treated with a low cholesterol/low fat diet, an exercise program, and cholesterol-lowering prescription medication.

Cigarette smoking. The LT smoked about 1.5 packs per day since about 1974.

Hypertension (HTN). The LT's elevated blood pressure was first noticed in 2003, diagnosed in April 2004, and successfully treated with diet, exercise, and blood pressure-lowering prescription medication.

During his April 2004 PCP medical evaluation, the LT had a normal resting EKG. The LT was 70 inches tall and weighed 170 pounds, giving him a "normal" body mass index (BMI) of 24.3 kilograms per square meter (kg/m^2)[2]. He never complained of any angina-like symptoms. According to the LT's wife who had spoken to the LT about 15 minutes prior to the incident, he did not express any symptoms of cardiac-related problems.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this combination FD consisted of 77 uniformed career personnel and 129 volunteers, served a population of 87,000 in a 475 square mile area, and had 12 fire stations.

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In 2004, the FD responded to 5,968 calls: 169 structure fires, 243 wildland fires, 128 vehicle fires, 537 vehicle accidents, 3,333 emergency medical calls, 42 extrication calls, and 1,516 other calls, including false alarms and public service.

Training. The FD requires all career fire fighter applicants to complete an application, be at least 18 years of age, possess a high school diploma or equivalent, pass a written test, possess a valid state driver's license, pass a physical agility test (PAT) (described below), pass a physical examination, pass the National Firefighter Entry Examination, pass a background check, and pass two oral interviews prior to being hired. The newly hired fire fighter must be classified as a National Professional Qualification (NPQ) Firefighter 1, complete the Georgia Emergency Management Agency (GEMA) 8-hour "Awareness for initial response to hazardous materials incidents" course, possess a valid CPR "C" basic life support certification, possess an 8-hour first aid certification, complete a 6-hour oxygen therapy training class, and complete the GEMA auto extrication class prior to being assigned to station duty or being allowed to drive fire apparatus. The new hire must complete a 25-shift rotation (5 shifts with each of the 5 station Captains) to gain experience on the various types of apparatus (engine, aerial, self-contained breathing apparatus [SCBA] refill, air, and light). Career fire fighters work 24 hours on-duty, 0700 hours to 0700 hours, and are off-duty for 48 hours.

Physical Agility Test. All applicants are required to wear full protective clothing consisting of turnout coat, turnout pants, hood, gloves, SCBA, and helmet while taking the PAT. Applicants may not run at any time during the PAT. The PAT consists of seven tasks. Points are awarded for completion of each task; the candidate must score a minimum of 300 points out of a total of 400 points. In order to rank the candidates, the tasks are timed, however the completion time is only considered if there is a point tie. The PAT consists of the following tasks:

1. Hose advancement
2. Ladder climb
3. Victim drag
4. Flexibility exercise
5. Backboard patient lift
6. Ladder raise
7. Tool carry

Volunteer fire fighter candidates must complete an application, be 18 years of age, possess a high school diploma or equivalent, have a valid state driver's license, pass a background check, complete the FD Basic Firefighter Course, and attend at least two training or station meetings prior to being accepted. The member receives turnout gear and is allowed to perform duties based on his/her current level of training. The member is on probation for six months and must complete NPQ Firefighter 1 within one year or within two NPQ Firefighter 1 class periods, whichever is longer.

State fire fighter certification is mandatory for career fire fighters (NPQ Firefighter 1). There is a 120-hour mandatory annual refresher training requirement. The LT was certified as a Fire Fighter II, Driver/Operator, Emergency Medical Technician, and in hazardous materials operations. He had 26 years of fire fighting experience.

Pre-placement Physical Examination. A pre-placement physical examination is required by this FD for career applicants only. The contents of the examination are as follows:

- A complete medical history
- Physical examination

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- Vital signs
- Complete blood count
- SMA-20 blood chemistry test
- Vision screening
- Audiogram
- Urine drug screen
- Urinalysis
- Spirometry
- Resting EKG
- Chest x-ray

A County-contracted physician performs the medical examinations and forwards the clearance for duty decision to the County human resources office.

Periodic Evaluations. Required annual medical evaluations were scheduled to begin in April 2005 for career members and hazardous materials fire fighters. Volunteer fire fighters may participate on a voluntary basis. The contents of the examination are the same as the pre-placement physical examination except no chest x-ray or resting EKG is performed. SCBA clearance is required annually. A County-contracted physician performs the medical evaluations and forwards the clearance for duty decision to the County human resources office, who makes the final determination. Additionally, annual calcium scoring (non-invasive computed tomography to assess coronary artery calcium deposits) is performed for all FD members.

No annual physical agility test is required for members. There is a voluntary fitness program with a protocol outlining specific recommended exercises. Exercise equipment (strength and aerobic) is available in some fire stations. A return-to-duty medical clearance is required from the County-contracted physician for duty-related injuries. A return-to-duty medical clearance is required from the fire fighter's PCP for illnesses that prevent fire fighters from performing their duty for three days. The clearance is provided to the FD, who reviews it and makes a final determination regarding return to work.

DISCUSSION

Coronary Artery Disease (CAD) and the Pathophysiology of Sudden Cardiac Death. In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[3] Risk factors for its development include age over 45, male gender, family history of CAD, smoking, high blood pressure (systolic >140 mmHg or diastolic > 90 mmHg), high blood cholesterol (total cholesterol > 240 mg/dL), obesity/physical inactivity, and diabetes.[4,5] The LT had five of these risk factors (age over 45, male gender, smoking, high blood pressure, and high cholesterol).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[6] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[7] Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[8] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. The LT had an acute heart attack identified by EKG changes, elevated cardiac isoenzymes, and a blood clot in the right coronary artery identified during his emergent cardiac catheterization.

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[9-12] The LT's heart attack and eventual death was possibly triggered by the physical exertion associated with washing the engine and the Squad

truck and his underlying atherosclerotic coronary artery disease (CAD) .

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.[13] NFPA 1582 recommends that, as part of its annex for informational purposes only, asymptomatic fire fighters with two or more risk factors for CAD be screened for obstructive CAD by an exercise stress test (EST). NFPA defines these CAD risk factors as: family history of premature (first degree relative less than age 60) cardiac event, hypertension (diastolic blood pressure greater than 90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia (total blood cholesterol level greater than 240 mg/dL).[13] This guidance is similar to recommendations from the American College of Cardiology/American Heart Association (ACC/AHA) and the Department of Transportation (DOT) regarding EST in asymptomatic individuals.[14,15] Since the LT had three "NFPA" CAD risk factors (high blood pressure, smoking, and hypercholesterolemia), an EST would have been consistent with NFPA 1582 guidance. In the NFPA 1582 annex, submaximal EST using a treadmill, bicycle, or stair climber are approved.[13] On this point, NFPA 1582 is not consistent with recommendations from the ACC/AHA. The ACC/AHA recommends a symptom limiting maximal EST rather than an arbitrary percentage of predicted maximum heart rate.[14]

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to prevent similar incidents or to address general safety and health issues:

Recommendation #1: Provide pre-placement and annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*,[13] in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative,[16] and the National Volunteer Fire Council (NVFC) Health and Wellness Guide.[17] The annual medical examination should include a chest x-ray (as indicated) and a resting EKG and should be offered to all fire fighters. However, the FD is not legally required to follow any of these standards.

Applying NFPA 1582 involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapter 8-7.1 and 8-7.2[18]and the NVFC Health and Wellness Guide[17] address these issues.

The physical evaluation could be conducted by the fire fighter's primary care physician or a City/County-contracted physician. If the evaluation is performed by the fire fighter's primary care physician, the results must be communicated to the City or County physician, who makes the final determination for clearance for duty.

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Recommendation #2: Consider conducting exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative recommend EST for fire fighters with two or more CAD risk factors.[13,16] The AHA states EST may be indicated for individuals over 45 years of age with two or more risk factors for CAD.[14] The EST could be conducted by the fire fighter's personal physician or the City/County contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City/County physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

Recommendation #3: Phase in a MANDATORY wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Physical inactivity, or lack of exercise, is associated with other CAD risk factors: obesity and diabetes.[19] NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[18] NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, provides the minimum requirements for a health-related fitness program.[20] In 1997, the IAFF and the IAFC published a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and create a practical fire service program. They produced a manual and a video detailing elements of such a program.[16] Large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[21-23] A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[24]

Recommendation #4: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.[18]

Recommendation #5: Staff all fire stations with a minimum of two fire fighters.

In this incident, an extra person on duty at all fire stations would probably not have changed the outcome. However, six of the twelve fire stations in this FD are staffed with one career person, the Driver/Operator. At least one additional engine staffed with two career personnel, a ladder truck staffed with three career personnel, a squad staffed with one career person, one Chief, and volunteers responding from their homes are dispatched to all residential structure fires. While there are specific requirements for fire station facility safety,[18,25] there is currently no

specific requirement to staff a fire station with a minimum of two personnel. NFPA 1710 requires that "on-duty personnel assigned to fire suppression shall be organized into company units and shall have appropriate apparatus and equipment assigned to such companies."[26] Those companies may respond with two apparatus, depending on the seating configuration of the apparatus to ensure four personnel arrive on scene.[26] Personnel assigned to the initial arriving company shall have the capability to implement an initial rapid intervention crew (IRIC),[26] which requires four personnel (two to enter the structure and two standing by outside). NFPA 1500 recommends that "members operating in hazardous areas at emergency incidents shall operate in teams of two or more."[18] Understaffing causes those members on-scene to work harder and for longer periods of time. Additionally, it requires the use of extra fire companies in order to meet the demand for manpower. Responding engine companies should be staffed with four personnel at a minimum. While the Fire Department is an emergency response agency, and paid members staff half of the fire stations, the remainder of the fire stations should be staffed with at least two persons per shift for safety considerations.

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